

Basic Ecological Principles: Understanding How the System Works

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Fact Sheet 5

Forestry and Natural Resources

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To understand wildlife management, landowners should know about some basic processes that go on in nature. Numerous wildlife management decisions are based on these principles. To help describe these natural processes, we must talk about ecology.

Ecology, in part, means the study of how and where plants and animals live. From a wildlife standpoint, think of ecology as the relationship between wild animals and their surroundings. A word we often use when discussing an animal's surroundings is environment. **Ecology** is the relationship between living things and their environment.

To understand animal ecology and how a landowner can affect it, we need to discuss the biological spectrum. The natural world is not randomly arranged in a helter-skelter manner, rather, it is organized into a scale of increasing structural and organizational complexity. This is what biologists refer to as the biological system (Figure 1).

One example of the organization and interrelationships found in nature is how a species is related to its ecosystem. We can define an ecosystem by understanding the concepts of species and environment.

We traditionally define an animal species in terms of its reproduction. We typically recognize a species as a group of individuals that:

- successfully breed with one another,
- share ties of common parentage, and
- possess a pool of common genes.

Stated more simply, a **species** is a group of plants or animals that have the same chromosomes and breed solely with each other. For example, take game species found on a particular tract of land such as white-tailed deer, raccoons, and gray squirrels. You recognize these animals as being different from one another. All the individuals of a given species living in the same location are referred to as a **population**. For example, all the gray squirrels in a particular woodlot constitute a population. That same woodlot could also be home to a population of bobwhite quail or raccoons, depending on the size of the woodlot. If we discuss all the animals in a specific area (e.g., all the wildlife populations on the Jones Farm or all the fish populations in Lake Marion) we would be talking about the community of wildlife on the Jones Farm or the community of fish in Lake Marion.

All the animals and plants in an area (the community) and their surroundings (the environment) comprise an **ecosystem**. Putting these concepts together, we start to get an idea of the biological spectrum and the organization found in nature.

As biologists learned more about the biological spectrum, they became more aware that disturbance to one part of nature is never just localized. Much like the ripples created by throwing a rock into a pond, the repercussions of an impact made on a species or community are felt throughout the system. The "ripples" of disturbance affect all parts of the natural spectrum.

Nature at Work

The relationships within an ecological system are always changing. Members of an animal species are being born or are dying, and these changes affect a wildlife population, community, and ecosystem. Many of the changes occurring within an ecosystem depend directly or indirectly on a number of natural processes or cycles. How well these natural cycles operate, or if they operate at all, often depends on individual landowners because they decide what happens on their property.

The functions of an ecosystem depend on energy provided by sunlight. The sun's energy, captured by green plants, is used for growth. The energy is stored as starches, proteins, or other vital components. The

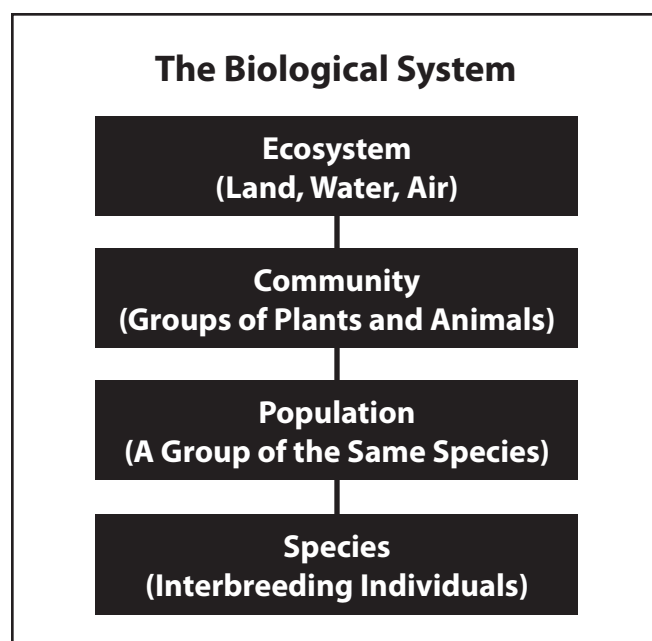


Figure 1. The Biological System

efficiency with which green plants transform and store solar energy from the sun is relatively low.

Efficient or not, plants are the most effective mechanism for converting solar energy into forms useful to animals and humans. This ability of plants makes them the basis for one of the most fundamental natural concepts: the **food chain**. The concept of a food chain often suggests the idea of “the little fish being eaten by the bigger fish” and is a general description of how a food chain operates. But food chains are much more involved than one animal eating another.

Food chains are made up of producers, consumers, and decomposers. Plants are normally the major producers in a food chain because they take energy from the sun and convert it into a form usable by other creatures.

Consumers fall mainly into 3 categories: herbivores, carnivores, and omnivores. Herbivores are those animals which eat only plants. These animals generally have a specialized digestive system (like those found in rabbits, deer, or cattle) which cannot break down foods other than plants. Carnivores are meat-eaters. Even though many carnivores eat grasses at various times during the year, for the most part, they depend on meat. They consume plant material mainly to help clean out their digestive system. For example, coyotes and foxes eat berries and fruits during the summer and fall. Omnivores are unique animals that eat both plant and animal matter. An example of an omnivore is the black bear.

Decomposers are organisms, like bacteria, fungi, and some insects, that help break down dead plant and animal material. Decomposers help return (recycle) nutrients and minerals to the natural system.

Let’s examine a simple food chain found in operation here in South Carolina. The plant (clover) converts the sun’s energy into useful compounds that are stored in its leaves and roots. The rabbit eats the clover to obtain the energy, protein, minerals, and other nutrients. If unfortunate enough to get caught by the red fox, the rabbit, through the nutrients in its tissues, would then be used to meet the nutrient requirements of the fox’s body.

What about the decomposers? When animals or plants die, nutrients in their bodies are returned to the environment by decomposers. The nutrients and minerals are released into the soil and recycled by other plants, producing more plant material, which feeds more rabbits and eventually more foxes.

Each step in a food chain contains energy. Each consumer will use about 90% of the energy it consumes to meet its basic needs (e.g., warm-blooded species use energy to maintain their internal body temperature). That means only 10% of the energy available at any level of a food chain can be used for anything other than life support. In our example of a food chain, only 10% of the energy obtained when the rabbit eats clover will be available for growth (if it is a young rabbit) or reproduction (if it is a pregnant female or a female with a litter of young).

Natural food chains are interconnected and form a **food web**. The term “web” is used to point out how things in nature are interrelated. In our food chain, the rabbit could be food for a number of other carnivores (coyotes, hawks, owls, etc.) and would be involved in several other food chains.

The Natural Cycle

Plants and decomposers are an important part of any food web, but are also important in another natural cycle, the mineral cycle. All plants and animals need minerals to survive, and wildlife obtain minerals from food. Carnivores obtain minerals from the animals they consume, whereas herbivores absorb the minerals they require from the plants they eat. Where do plants get the minerals they need, and why is it that the supply of minerals in nature does not run out? This is a simple question with a lengthy answer. Farmers or homeowners often apply fertilizers to their fields or lawns to produce more corn, soybeans, and wheat or to keep their lawn lush and green. This is an example of how plants need and respond to minerals. Most fertilizers contain 3 basic minerals: nitrogen, phosphorus, and potassium. Just as crops and lawns need minerals to grow and produce, so do the plants found in natural environments. No one applies fertilizer to plants in the forest because decomposers, through the mineral cycle, provide most of the minerals to sustain plant life.

Most of the minerals needed by plants occur either as a gas in the atmosphere or as a mineral in the soil. Plants get the minerals that occur as a gas, such as carbon in carbon dioxide, through their leaves. Small openings, called stomata, on the underside of leaves allow plants to take in various atmospheric gases.

Plants can also absorb minerals through their roots. The minerals may be available in the soil as a result of natural processes such as erosion or through the activity of special soil bacteria. Once absorbed by plants, the minerals become available to herbivores. After the herbivores have eaten the plants and taken the minerals into their bodies, the minerals are now available to any carnivore who eats the herbivore.

Plants are essential for wildlife because they provide the minerals animals need to survive. Animals must get the majority of minerals they need from their diet. However, sometimes sodium, phosphorus, or other minerals are in short supply, and wildlife can obtain minerals by eating soil (e.g., deer eating soil at a salt lick) or by chewing on shed deer antlers or bones.

Let’s go back to the question of why the supply of minerals in natural environments never runs out if plants are taking them out of the atmosphere and soil. As discussed earlier, all plants and animals take minerals into their tissues. When a rabbit or clover plant dies, it decomposes or rots. The decomposers, organisms like fungi (mushrooms, toadstools, etc.) and bacteria, feed on dead plants or animals and break them down.

This breakdown results in a release of either minerals and nutrients which plants can use or gaseous byproducts which help replenish

the supply of atmospheric gases. Because the mineral cycle supplies most plant and animal requirements, no one needs to apply fertilizer in a forest. Food chains, food webs, and mineral cycles are examples of how natural processes, if allowed to function properly, contribute to the “balance” of nature and well-being of all wildlife. Therefore, a landowner can adversely affect this delicate balance in 2 ways:

- by spraying a herbicide which may eliminate some food plants on which wildlife depend or which may destroy bacteria, fungi, and other decomposers in the soil; or
- by applying a pesticide to eliminate certain soil pests.

In either case, all wildlife in the area may suffer.

Plant Communities

Matching land management with wildlife needs requires an understanding of another natural process called plant succession. Plant communities are not fixed in time, changing as the types and numbers of plants in an area change. Most landowners know about plant succession; they just refer to it by different terms. When fields have been abandoned and people talk about the field “going back to woods,” they are talking about plant succession.

Plant succession is nothing more than a change in plant communities over time. Just as plant communities change from annual weeds to the final community of oaks and hickories, animal communities also change (Table 1).

Let’s examine plant succession and how changes in plant communities can affect wildlife. Consider an abandoned soybean field in South Carolina. During the first year, light, airborne-seeded plants such as beggar ticks become established. At this time, mourning doves and songbirds find the area desirable because they feed on seeds produced by **annual weeds** (those which grow, produce seed, and die each year), such as ragweed and foxtail grass. As time goes by, the field will become filled with heavy-seeded **perennial** (plants which survive for more than one year) weeds, grasses, and legumes. This type of plant community favors quail, cottontail rabbit, and numerous other small mammals like voles or deer mice. In turn, these species provide abundant food for red foxes, coyotes, hawks, and owls. Turkey broods find such areas useful for feeding on seeds and insects. During the third to eighth year, broomsedge, grasses, blackberries, and hardwood tree sprouts form briar thickets and other thick, brushy areas, creating habitats that favor cottontail rabbits, deer, and many species of songbirds. Deer browse and cover are generally greater during this period than at any other time. Nesting sites for dove, quail, and turkeys are abundant during this stage.

As the shrubs and trees grow larger and begin to shade the ground, the weeds that once grew in the field start to get shaded out. As the trees grow larger, they start to shade out even more plant life growing on the ground. A wide variety of wildlife will use these areas for nesting and cover.

As the forest matures, a plant community appears that is not replaced as long as major climate changes do not occur. This last community may survive for hundreds of years or until something happens to disturb the community. This relatively stable, long-term plant community is called the **climax community**. In much of South Carolina, the climax community is the mixed oak-hickory forest.

During the final stages of succession, cavity-nesting wildlife such as raccoons, tree squirrels, and owls, in addition to turkey and gray fox, flourish.

Each species of wild animal thrives only in those plant successional stages that can meet its requirements for survival. Some animals require that a specific stage of plant succession be abundant for their population levels to be high (cottontail rabbits need shrub fields, for example), whereas other species (white-tailed deer) need to have a variety of plant successional stages available to meet their needs.

Generally, during succession the number of different species or diversity increases with each successive plant community. However, the climax community does not have the greatest variety of species. Diversity peaks some time before the climax community appears.

Why Animals Live Where They Do?

Why are certain wildlife species attracted to different stages of plant succession? Again, this is a simple question with a complex answer. All wild animals live within a range of tolerance for each of the physical and biological components of their environment. For instance, there is a range of temperatures in which a gray squirrel, quail or trout can survive and reproduce. If it becomes too hot or too cold, the animal cannot function normally.

All animals die when critical bodily functions are reduced or stopped. Different ranges of tolerances restrict species within certain environments. For example, the ptarmigan-arctic grouse cannot survive as far south as Michigan because it is not adapted for the climate there. Therefore, groups of animal species with similar tolerances form communities within ecosystems.

Plants and animals survive as long as they can compete successfully for resources. When an animal can no longer compete for food, for the right to breed, or for the resources necessary to its survival, it is doomed to disappear.

Each species of plant or animal is the product of a long history controlled mainly by adaptation and competition. The genes of individuals that can compete and adapt to their environment are passed onto the next generation. Individuals that cannot compete are eventually eliminated. As a result, species are constantly adapting to their environment. Therefore, each species has a unique role in an ecosystem. This role or “job” an animal performs in an ecosystem is known as its niche. Some wild animals are so adapted to their particular environment that they cannot survive well without it. These species have a very narrow range of tolerance, and we call these individuals **specialists** (Figure 2).

Table 1. Common terrestrial vertebrate species along a successional gradient of an oak-hickory forest.

Grass-Forb	Shrub	Shrub-Small Tree	Mature Forest
Birds			
dark-eyed junco*	cardinal	bobwhite	redeyed vireo
red-winged blackbird	dark-eyed junco*	rufous-sided towhee	scarlet tanager
eastern meadowlark	bobwhite	cardinal	summer tanager
eastern kingbird	rufous-sided towhee	brown thrasher	tufted titmouse
American goldfinch	prairie warbler	yellow-breasted chat	great-crested flycatcher
prairie warbler	common yellowthroat	white-eyed vireo	ovenbird
field sparrow	mockingbird	blue jay	red-bellied woodpecker
grasshopper sparrow	indigo bunting	Carolina chickadee	blue-gray gnatcatcher
mourning dove	white-eyed vireo		
white-throated sparrow*	yellow-breasted chat		
	white-throated sparrow*		
Mammals			
meadow vole	meadow vole	white-footed mouse	white-footed mouse
deer mouse	white-footed mouse	short-tailed shrew	short-tailed shrew
least shrew	least shrew	white-tailed deer	southeastern shrew
short-tailed shrew	short-tailed shrew	golden mouse	red bat
eastern mole	white-tailed deer	eastern chipmunk	eastern chipmunk
woodchuck	golden mouse	fox squirrel	gray squirrel
	eastern cottontail		flying squirrel
	woodchuck		
Reptiles and Amphibians			
garter snake	black racer	American toad	slimy salamander
black racer	five-lined skink	box turtle	black rat snake
box turtle	box turtle	copperhead	American toad
American toad	American toad	rough green snake	hognose snake
hognose snake	hognose snake	fence lizard	fence lizard
leopard frog	ribbon snake	five-lined skink	copperhead
		broad-headed skink	
*winter resident			

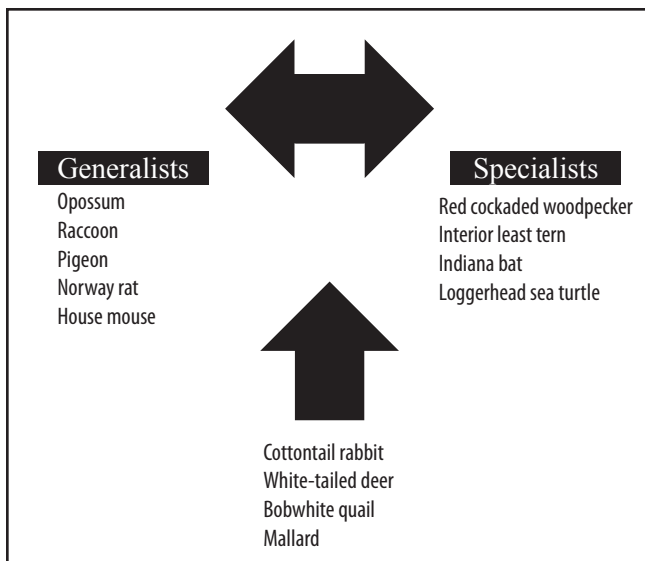


Figure 2. Generalists and Specialists

Specialists are often the animals we hear about when people refer to wildlife that are in danger of extinction (endangered species).

Other species are **generalists** that can deal with a broad set of environmental conditions. These animals prosper under new conditions and are frequently the wildlife adjusting well to environments created by towns and cities (opossums, house mice, starlings, coyotes). Whether they are specialists or generalists, all animals have a unique ability for living within their own range of tolerance. Even though it may appear that two animal species have similar “jobs,” no two species are exactly the same. For instance, robins and woodcock both feed largely on earthworms, but each finds food in a different way and in different locations. Robins feed at the soil surface in open areas, and they locate their prey by sight. Woodcock poke about in moist forested soils and have long bills equipped with sensitive nerves for detecting the underground movements of worms. This way the species avoid competition, and their niches do not overlap.

The Big Picture

With an understanding of some of the basic ecological processes that function in nature, landowners are likely to recognize that:

- changing a natural community for any purpose will alter the patterns in which energy and matter flow through an ecosystem;
- communities vary in their tolerance for disturbance;
- as plant communities change through succession, animal communities also change;
- effectively managing wildlife on private property means recognizing the degree to which communities are disrupted when plant and animal populations are manipulated; and
- as a property owner, landowners are the “landlord” or “steward” of all wildlife on their land.